Assignment - 2 k-NN for classification.

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```
#install.packages("readr")
library(readr)
#install.packages("lattice")
library(lattice)
#install.packages("caret")
library(caret)
```

```
## Loading required package: ggplot2
```

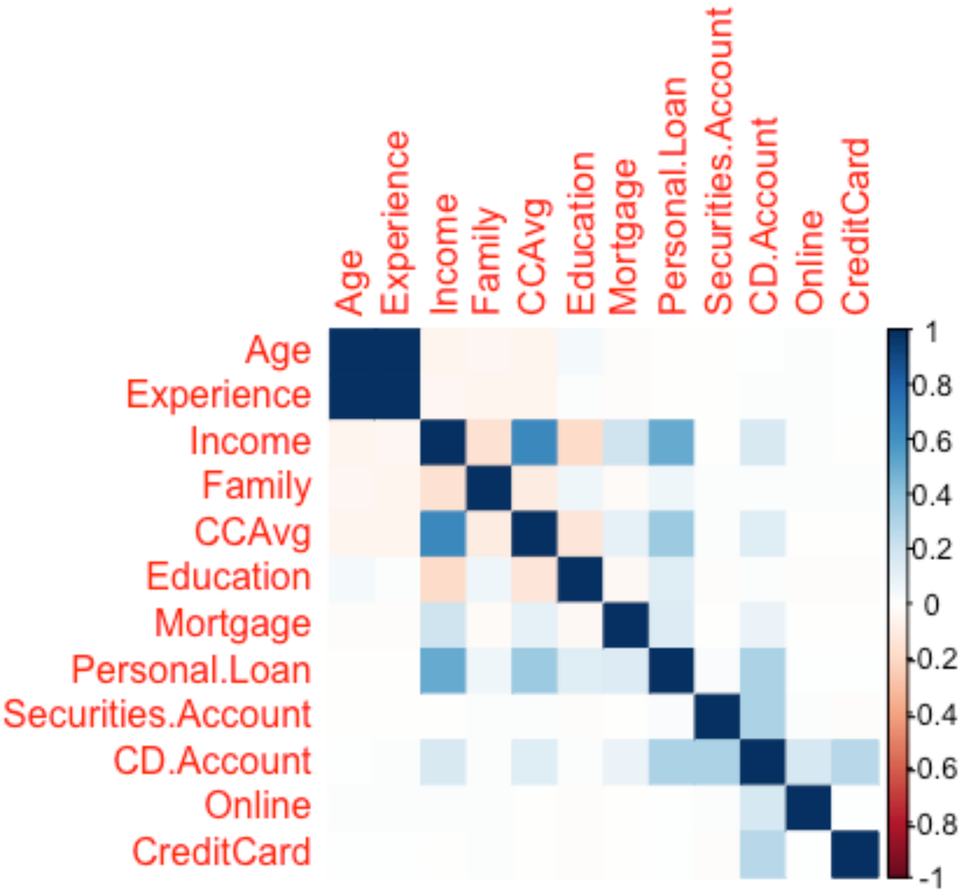
```
#install.packages("ISLR")
library(ISLR)
#install.packages("ggplot2")
library(ggplot2)
#install.packages("corrplot")
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
#install.packages("fastDummies")
library(fastDummies)
#install.packages("FNN")
library(FNN)
#install.packages("plyr")
library("plyr")
#install.packages("gmodels")
library(gmodels)
#install.packages("ggplot2")
library(ggplot2)
```

#Importing Data, Data visulization & Data Summary

```
options(stringsAsFactors = FALSE)
UniversalBank <- read.csv("~/Desktop/FML/UniversalBank.csv")
Universalbank_num <-UniversalBank [, c(2:4,6:14)]
corrplot(cor(Universalbank_num), method="color")
```



```
summary(Universalbank_num)

##       Age          Experience       Income           Family
##  Min.   :23.00   Min.   :-3.0   Min.   :  8.00   Min.   :1.000
##  1st Qu.:35.00   1st Qu.:10.0   1st Qu.: 39.00   1st Qu.:1.000
##  Median :45.00   Median :20.0   Median : 64.00   Median :2.000
##  Mean   :45.34   Mean   :20.1   Mean   : 73.77   Mean   :2.396
##  3rd Qu.:55.00   3rd Qu.:30.0   3rd Qu.: 98.00   3rd Qu.:3.000
##  Max.   :67.00   Max.   :43.0   Max.   :224.00   Max.   :4.000
##      CCAvg          Education        Mortgage     Personal.Loan
##  Min.   : 0.000   Min.   :1.000   Min.   :  0.0   Min.   :0.000
##  1st Qu.: 0.700   1st Qu.:1.000   1st Qu.:  0.0   1st Qu.:0.000
##  Median : 1.500   Median :2.000   Median :  0.0   Median :0.000
##  Mean   : 1.938   Mean   :1.881   Mean   : 56.5   Mean   :0.096
##  3rd Qu.: 2.500   3rd Qu.:3.000   3rd Qu.:101.0   3rd Qu.:0.000
##  Max.   :10.000   Max.   :3.000   Max.   :635.0   Max.   :1.000
##  Securities.Account   CD.Account         Online          CreditCard
##  Min.   :0.0000     Min.   :0.0000    Min.   :0.0000   Min.   :0.000
##  1st Qu.:0.0000     1st Qu.:0.0000    1st Qu.:0.0000   1st Qu.:0.000
##  Median :0.0000     Median :0.0000    Median :1.0000   Median :0.000
##  Mean   :0.1044     Mean   :0.0604    Mean   :0.5968   Mean   :0.294
##  3rd Qu.:0.0000     3rd Qu.:0.0000    3rd Qu.:1.0000   3rd Qu.:1.000
##  Max.   :1.0000     Max.   :1.0000    Max.   :1.0000   Max.   :1.000
```

```
head(UniversalBank,10)

##    ID Age Experience Income ZIP.Code Family CCAvg Education Mortgage
## 1   1  25          1     49    91107      4   1.6         1        0
## 2   2  45         19     34    90089      3   1.5         1        0
## 3   3  39         15     11    94720      1   1.0         1        0
## 4   4  35          9    100    94112      1   2.7         2        0
## 5   5  35          8     45    91330      4   1.0         2        0
## 6   6  37         13     29    92121      4   0.4         2      155
## 7   7  53         27     72    91711      2   1.5         2        0
## 8   8  50         24     22    93943      1   0.3         3        0
## 9   9  35         10     81    90089      3   0.6         2      104
## 10 10  34          9    180    93023      1   8.9         3        0
##    Personal.Loan Securities.Account CD.Account Online CreditCard
## 1              0                  1          0      0          0
## 2              0                  1          0      0          0
## 3              0                  0          0      0          0
## 4              0                  0          0      0          0
## 5              0                  0          0      0          1
## 6              0                  0          0      1          0
## 7              0                  0          0      1          0
## 8              0                  0          0      0          1
## 9              0                  0          0      1          0
## 10             1                  0          0      0          0
```

#Convert Education to dummy variables

```
Universalbank_dummy <- dummy_cols(Universalbank_num, select_columns =
"Education")
```

#Splitting data Training : 60% , Validation : 40%

```
set.seed(1)
#splitting 60% of data into training & 40% of data into validation
Train_index <- createDataPartition(Universalbank_dummy$'Personal.Loan',
p=0.6, list=FALSE)
Training_data <-Universalbank_dummy[Train_index,]
Validation_data <-Universalbank_dummy [-Train_index,]
summary(Training_data)

##       Age          Experience        Income           Family     
##  Min.   :23.00   Min.   :-3.00   Min.   :  8.00   Min.   :1.000  
##  1st Qu.:36.00   1st Qu.:10.00   1st Qu.: 39.00   1st Qu.:1.000  
##  Median :45.00   Median :20.00   Median : 63.00   Median :2.000  
##  Mean   :45.43   Mean   :20.19   Mean   : 73.08   Mean   :2.388  
##  3rd Qu.:55.00   3rd Qu.:30.00   3rd Qu.: 98.00   3rd Qu.:3.000  
##  Max.   :67.00   Max.   :43.00   Max.   :224.00   Max.   :4.000  
##      CCAvg          Education       Mortgage      Personal.Loan  
##  Min.   : 0.000   Min.   :1.00   Min.   :  0.00   Min.   :0.00000  
##  1st Qu.: 0.700   1st Qu.:1.00   1st Qu.:  0.00   1st Qu.:0.00000  
##  Median : 1.500   Median :2.00   Median :  0.00   Median :0.00000  
##  Mean   : 1.915   Mean   :1.88   Mean   : 57.34   Mean   :0.09167
##  3rd Qu.: 2.500   3rd Qu.:3.00   3rd Qu.:102.00   3rd Qu.:0.00000
##  Max.   :10.000   Max.   :3.00   Max.   :635.00   Max.   :1.00000
##  Securities.Account   CD.Account          Online         CreditCard
##  Min.   :0.0000     Min.   :0.00000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.0000     1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.0000
##  Median :0.0000     Median :0.00000   Median :1.0000   Median :0.0000
##  Mean   :0.1003     Mean   :0.05367   Mean   :0.5847   Mean   :0.2927
##  3rd Qu.:0.0000     3rd Qu.:0.00000   3rd Qu.:1.0000   3rd Qu.:1.0000
##  Max.   :1.0000     Max.   :1.00000   Max.   :1.0000   Max.   :1.0000
##   Education_1      Education_2     Education_3
##  Min.   :0.0000   Min.   :0.000   Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.000   1st Qu.:0.0000
##  Median :0.0000   Median :0.000   Median :0.0000
##  Mean   :0.4173   Mean   :0.285   Mean   :0.2977
##  3rd Qu.:1.0000   3rd Qu.:1.000   3rd Qu.:1.0000
##  Max.   :1.0000   Max.   :1.000   Max.   :1.0000
```

```
summary(Validation_data)
```

```
##       Age         Experience        Income           Family
##  Min.   :23.0   Min.   :-3.00   Min.   :  8.00   Min.   :1.000
##  1st Qu.:35.0   1st Qu.:10.00   1st Qu.: 39.00   1st Qu.:1.000
##  Median :45.0   Median :20.00   Median : 64.00   Median :2.000
##  Mean   :45.2   Mean   :19.97   Mean   : 74.81   Mean   :2.409
##  3rd Qu.:55.0   3rd Qu.:30.00   3rd Qu.: 99.00   3rd Qu.:3.000
##  Max.   :67.0   Max.   :43.00   Max.   :218.00   Max.   :4.000
##      CCAvg          Education        Mortgage      Personal.Loan
##  Min.   : 0.000   Min.   :1.000   Min.   :  0.00   Min.   :0.0000
##  1st Qu.: 0.700   1st Qu.:1.000   1st Qu.:  0.00   1st Qu.:0.0000
##  Median : 1.600   Median :2.000   Median :  0.00   Median :0.0000
##  Mean   : 1.973   Mean   :1.882   Mean   : 55.24   Mean   :0.1025
##  3rd Qu.: 2.600   3rd Qu.:3.000   3rd Qu.: 97.25   3rd Qu.:0.0000
##  Max.   :10.000   Max.   :3.000   Max.   :617.00   Max.   :1.0000
##  Securities.Account   CD.Account         Online        CreditCard
##  Min.   :0.0000     Min.   :0.0000   Min.   :0.000   Min.   :0.000
##  1st Qu.:0.0000     1st Qu.:0.0000   1st Qu.:0.000   1st Qu.:0.000
##  Median :0.0000     Median :0.0000   Median :1.000   Median :0.000
##  Mean   :0.1105     Mean   :0.0705   Mean   :0.615   Mean   :0.296
##  3rd Qu.:0.0000     3rd Qu.:0.0000   3rd Qu.:1.000   3rd Qu.:1.000
##  Max.   :1.0000     Max.   :1.0000   Max.   :1.000   Max.   :1.000
##   Education_1     Education_2     Education_3
##  Min.   :0.000   Min.   :0.000   Min.   :0.000
##  1st Qu.:0.000   1st Qu.:0.000   1st Qu.:0.000
##  Median :0.000   Median :0.000   Median :0.000
##  Mean   :0.422   Mean   :0.274   Mean   :0.304
##  3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:1.000
##  Max.   :1.000   Max.   :1.000   Max.   :1.000
```

```
#checking Frequency of personal Loan splited properly or not
count(Training_data$`Personal.Loan`)

##   x freq
## 1 0 2725
## 2 1  275

count(Validation_data$`Personal.Loan`)

##   x freq
## 1 0 1795
## 2 1  205
```

#Data Normalization

```
train.normalized.df <- Training_data
valid.normalized.df <- Validation_data
norm.values <- preProcess(Training_data[, 1:7], method=c("center", "scale"))
#Replacing columns with normalized values
train.normalized.df [, 1:7]  <- predict(norm.values,Training_data[,1:7])
valid.normalized.df [, 1:7]  <- predict(norm.values, Validation_data[,1:7])
```

#KNN Modeling

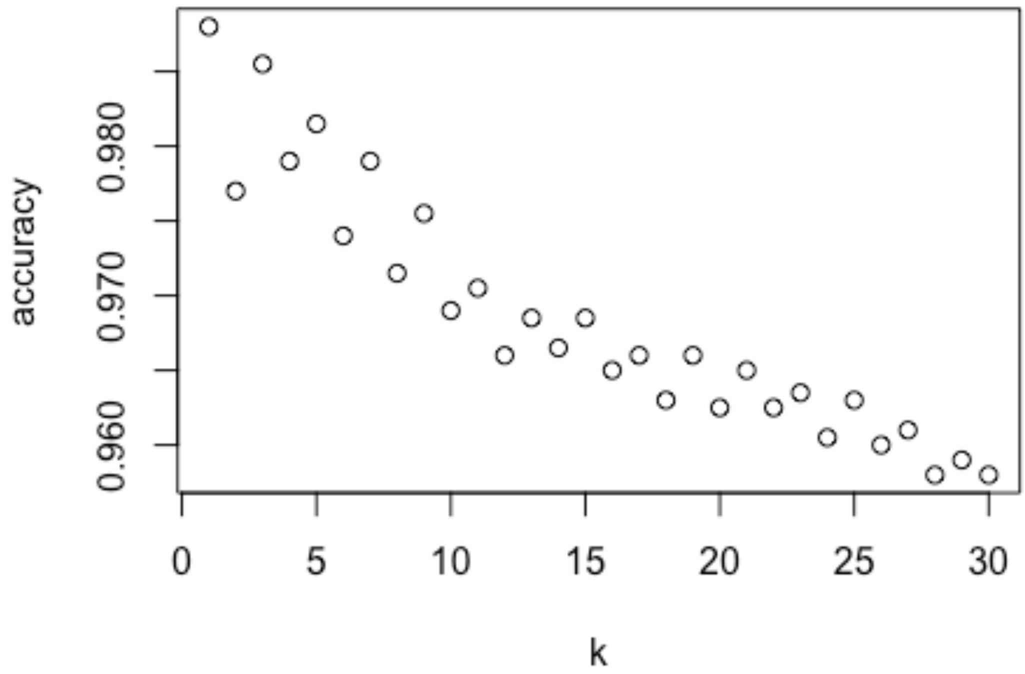
```
cl= as.data.frame(train.normalized.df[,8])
tnf = as.data.frame(train.normalized.df)
vnf = as.data.frame(valid.normalized.df)
dim(cl)

## [1] 3000    1

dim(train.normalized.df[,1:7])

## [1] 3000    7

dim(valid.normalized.df[,1:7])

## [1] 2000    7

knn_predict <- knn(tnf, vnf, cl=train.normalized.df$`Personal.Loan`, k =1)
head(knn_predict)

## [1] 0 0 0 0 1 0
## Levels: 0 1

knn_predict <- as.data.frame(knn_predict)
```

#assess Data to model

```
customer_df <- data.frame ("Age" =40, "Experience"=10, "Income"=84,
"Family"=2, "CCAvg"=2, "Education_1"=0, "Education_2"=1, "Education_3"=0,
"Mortgage"=0,  "Securities Account"=0, "CD Account"=0,  "Online" =1, "Credit
Card"=1)
```

```
dim(tnf)

## [1] 3000   15

dim(customer_df)

## [1]  1 13

customerClass <- knn ((tnf[, c(-6, -8)]), (customer_df),  cl =
train.normalized.df$`Personal.Loan`, k = 1, prob = 0.5)

summary(customerClass)  #CUSTOMER class is 1. Customer is likely to accept a
personal loan according to this model.

## 1
## 1

#library(lattice)
#library(ggplot2)
#library(caret)
accuracy.df <- data.frame(k= seq (1, 30, 1), accuracy = rep(0, 30))
for( i in 1:30) {
    prediction <- knn ( tnf,  vnf,  cl = train.normalized.df$`Personal.Loan`,
k = i)
    accuracy.df[i, 2] <- confusionMatrix ( as.factor (prediction), as.factor(
valid.normalized.df$`Personal.Loan`))$overall[1]
}
accuracy.df

##     k accuracy
## 1   1   0.9880
## 2   2   0.9770
## 3   3   0.9855
## 4   4   0.9790
## 5   5   0.9815
## 6   6   0.9740
## 7   7   0.9790
## 8   8   0.9715
## 9   9   0.9755
## 10 10   0.9690
## 11 11   0.9705
## 12 12   0.9660
## 13 13   0.9685
## 14 14   0.9665
## 15 15   0.9685
## 16 16   0.9650
## 17 17   0.9660
## 18 18   0.9630
## 19 19   0.9660
## 20 20   0.9625
## 21 21   0.9650
## 22 22   0.9625
## 23 23   0.9635
## 24 24   0.9605
## 25 25   0.9630
## 26 26   0.9600
## 27 27   0.9610
## 28 28   0.9580
## 29 29   0.9590
## 30 30   0.9580
```

```
plot(accuracy.df)
```



#Confusion Matrix

```
#library(gmodels)
valid_labels <-as.data.frame( vnf[,8])

#Model accuracy = TP+TN/Total= 99%, specifity= 99.7%, percision= 98%
CrossTable( valid_labels$`vnf[, 8]`,  knn_predict$knn_predict,   prop.chisq =
FALSE)
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |           N / Row Total |
## |           N / Col Total |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  2000
##
##
##                         | knn_predict$knn_predict
## valid_labels$`vnf[, 8]` |         0 |         1 | Row Total |
## ------------------------|-----------|-----------|-----------|
##                       0 |      1795 |         0 |      1795 |
##                         |     1.000 |     0.000 |     0.897 |
##                         |     0.987 |     0.000 |           |
##                         |     0.897 |     0.000 |           |
## ------------------------|-----------|-----------|-----------|
##                       1 |        24 |       181 |       205 |
##                         |     0.117 |     0.883 |     0.102 |
##                         |     0.013 |     1.000 |           |
##                         |     0.012 |     0.090 |           |
## ------------------------|-----------|-----------|-----------|
##            Column Total |      1819 |       181 |      2000 |
##                         |     0.909 |     0.090 |           |
## ------------------------|-----------|-----------|-----------|
##
##
```

#Data Plinting into Training as 50% , Validation as 30% , Testing as 20%

```
set.seed(12)
Train_index2 <- createDataPartition(Universalbank_dummy$`Personal.Loan`,
p=0.50, list=FALSE)
Training_data2 <- Universalbank_dummy[Train_index2,]

CombinedValidation_test <- Universalbank_dummy [-Train_index2,]

Valid_index2 <- createDataPartition (CombinedValidation_test$`Personal.Loan`,
p=0.30, list=FALSE)
Validation_data2 <- CombinedValidation_test[Valid_index2,]
Test_data2 <- CombinedValidation_test[-Valid_index2,]
```

#Data Normalization

```
train.normalized.df2 <- Training_data2
valid.normalized.df2 <- Validation_data2
Test.normalized.df2 <- Test_data2
Combined_normalized2<-CombinedValidation_test
```

```
norm.values2 <- preProcess(Training_data2[, 1:7], method=c("center",
"scale"))

train.normalized.df2 [, 1:7]  <- predict(norm.values2, Training_data2[,1:7])
# Replace columns with normalized values
valid.normalized.df2 [, 1:7]  <- predict(norm.values2,
Validation_data2[,1:7])

Test.normalized.df2 [, 1:7] <- predict(norm.values2, Test_data2[, 1:7])

Combined_normalized2[, 1:7] <- predict(norm.values2,
CombinedValidation_test[,1:7])
```

#Modeling k-NN with validation data

```
#library(FNN)
cl2= as.data.frame(train.normalized.df2[,8])
tnf2 = as.data.frame(train.normalized.df2)
vnf2= as.data.frame(valid.normalized.df2)
dim(cl2)

## [1] 2500    1

dim(train.normalized.df2[,1:7])

## [1] 2500    7

dim(valid.normalized.df2[,1:7])

## [1] 750   7

knn_predict2 <- knn(tnf2, vnf2, cl=train.normalized.df2$`Personal.Loan`, k
=1)
head(knn_predict2)

## [1] 0 0 0 0 0 1
## Levels: 0 1

knn_predict2 <- as.data.frame(knn_predict2)
```

#predicting KNN using validation and test data

```
cl2= as.data.frame(train.normalized.df2[,8])
tnf2 = as.data.frame(train.normalized.df2)
cnf3= as.data.frame(Combined_normalized2)
dim(cl2)

## [1] 2500    1

dim(train.normalized.df2[,1:7])

## [1] 2500    7
```

```
dim(Combined_normalized2[,1:7])

## [1] 2500    7

knn_predict3 <- knn(tnf2, cnf3, cl=train.normalized.df2$`Personal.Loan`, k
=1)
head(knn_predict3)

## [1] 0 0 0 0 0 0
## Levels: 0 1

knn_predict3 <- as.data.frame(knn_predict3)



summary(knn_predict3)

##  knn_predict3
##  0:2295
##  1: 205
```

#Customer class

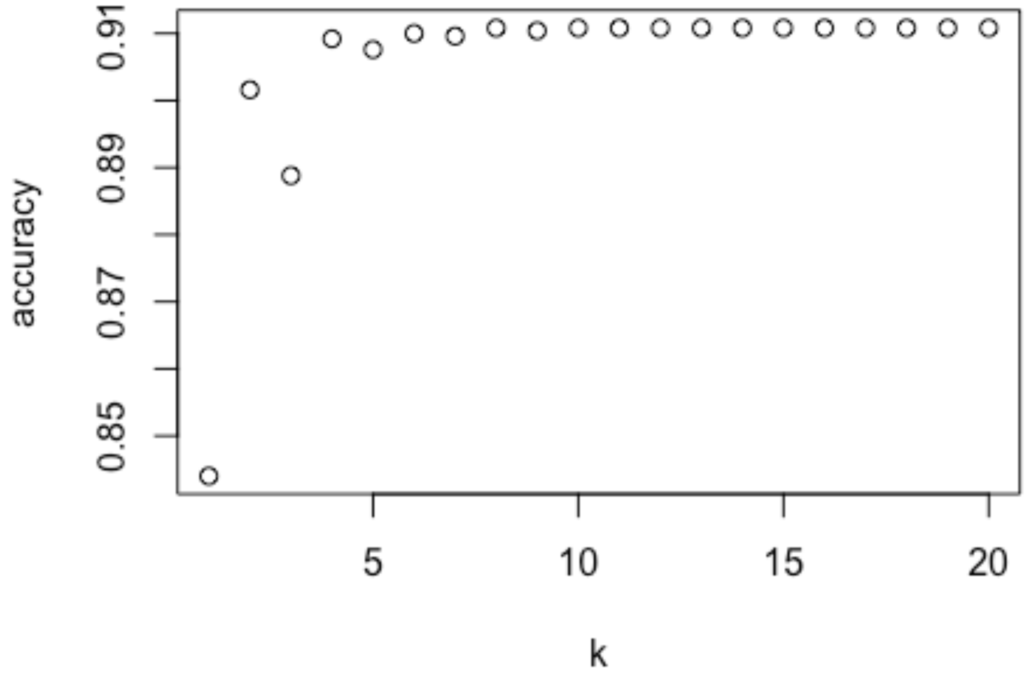
```
customer_df2 <- data.frame ("Age" =40, "Experience"=10, "Income"=84,
"Family"=2, "CCAvg"=2, "Education_1"=0, "Education_2"=1, "Education_3"=0,
"Mortgage"=0,  "Securities Account"=0, "CD Account"=0,  "Online" =1, "Credit
Card"=1)

dim(tnf2)

## [1] 2500   15

dim(customer_df2)

## [1]  1 13

customerClass2 <- knn ((tnf2[, c(-6, -8)]), (customer_df2),  cl =
Combined_normalized2$`Personal.Loan`, k = 1, prob = 0.5)
 #CUSTOMER class is  0. Customer is NOT likely to accept a personal loan
according to this model
summary(customerClass)

## 1
## 1

 # k= 8 gives the highest accuracy percentage of 91%
accuracy.df2 <- data.frame(k= seq (1, 20, 1), accuracy = rep(0, 20))

for( y in 1:20){
  prediction2 <- knn (tnf2, cnf3, cl= Combined_normalized2$`Personal.Loan`,
k = y)
  accuracy.df2[y, 2] <- confusionMatrix ( as.factor(prediction2) ,
as.factor(Combined_normalized2$`Personal.Loan`))$overall[1]
}
```

```
## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.

## Warning in confusionMatrix.default(as.factor(prediction2),
## as.factor(Combined_normalized2$Personal.Loan)): Levels are not in the same
order
## for reference and data. Refactoring data to match.
```

```
accuracy.df2
```

```
##     k accuracy
## 1   1   0.8440
## 2   2   0.9016
## 3   3   0.8888
## 4   4   0.9092
## 5   5   0.9076
## 6   6   0.9100
## 7   7   0.9096
## 8   8   0.9108
## 9   9   0.9104
## 10 10   0.9108
## 11 11   0.9108
## 12 12   0.9108
## 13 13   0.9108
## 14 14   0.9108
## 15 15   0.9108
## 16 16   0.9108
## 17 17   0.9108
## 18 18   0.9108
## 19 19   0.9108
## 20 20   0.9108
```

```
plot(accuracy.df2)
```



#Using only validation dataset

```
valid_labels2 <-as.data.frame( vnf2[,8])

CrossTable( valid_labels2$`vnf2[, 8]`,  knn_predict2$knn_predict2,
prop.chisq = FALSE)      #Model accuracy = TP+TN/Total= 99%, specifity= 99.9%,
percision= 99%, sesitivity =93%

##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |           N / Row Total |
## |           N / Col Total |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  750
##
##
##                           | knn_predict2$knn_predict2
## valid_labels2$`vnf2[, 8]` |         0 |         1 | Row Total |
## --------------------------|-----------|-----------|-----------|
##                          0 |       670 |         1 |       671 |
##                            |     0.999 |     0.001 |     0.895 |
##                            |     0.994 |     0.013 |           |
##                            |     0.893 |     0.001 |           |
## --------------------------|-----------|-----------|-----------|
##                          1 |         4 |        75 |        79 |
##                            |     0.051 |     0.949 |     0.105 |
##                            |     0.006 |     0.987 |           |
##                            |     0.005 |     0.100 |           |
## --------------------------|-----------|-----------|-----------|
##               Column Total |       674 |        76 |       750 |
##                            |     0.899 |     0.101 |           |
## --------------------------|-----------|-----------|-----------|
##
##
```

#Using combined validation and test datasets

```
valid_labels2 <-as.data.frame(cnf3[,8])
CrossTable( valid_labels2$`cnf3[, 8]`,  knn_predict3$knn_predict3,
prop.chisq = FALSE )     #Model accuracy = TP+TN/Total= 99.9%, specifity=
99.9%, percision= 98.7%, sesitivity =91% This model give highest results.
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |           N / Row Total |
## |           N / Col Total |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  2500
##
##
##                            | knn_predict3$knn_predict3
## valid_labels2$`cnf3[, 8]` |         0 |         1 | Row Total |
## --------------------------|-----------|-----------|-----------|
##                          0 |      2274 |         3 |      2277 |
##                            |     0.999 |     0.001 |     0.911 |
##                            |     0.991 |     0.015 |           |
##                            |     0.910 |     0.001 |           |
## --------------------------|-----------|-----------|-----------|
##                          1 |        21 |       202 |       223 |
##                            |     0.094 |     0.906 |     0.089 |
##                            |     0.009 |     0.985 |           |
##                            |     0.008 |     0.081 |           |
## --------------------------|-----------|-----------|-----------|
##              Column Total |      2295 |       205 |      2500 |
##                            |     0.918 |     0.082 |           |
## --------------------------|-----------|-----------|-----------|
##
##
```